POWER EFFICIENY OPTIMIZATION IN NONORTHOGONAL MULTIPLE ACCESS (NOMA) USING LONG SHORT-TERM MEMORY WITH PARTICLE SWARM OPTIMIZATION (LSTM-PSO) TECHNIQUE

A SYNOPSIS

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1. INTRODUCTION

Wireless communication has undergone a technological revolution in recent decades. High data rates and continuous connectivity are essential in modern technology due to the shift from basic voice communication to highly interactive multimedia applications. The demand for mobile devices is experiencing significant growth. Researchers are currently working on the development of fifth-generation (5G) and subsequent wireless communication networks to meet future demands. The current 5G and the future 6G, offer a numerous of advantages, including reduced latency, enhanced data transmission rates and improved user capacity. Non-Orthogonal Multiple Access (NOMA) increases receiver complexity, which in turn yields the aforementioned advantages. NOMA is a potentially effective solution for addressing the increasing demands of future wireless communication networks, including the need to accommodate a large number of users, meet connectivity requirements, minimize costs, optimize limited bandwidth, and ensure extensive coverage. NOMA-assisted wireless communication networks encounter both challenges and benefits. NOMA technology enhances user access and spectral efficiency.

A power-tolerant non-orthogonal multiple access (NOMA) scheme mitigates the system's susceptibility to inaccurate power allocation by dynamically adjusting the signal power of each user. The data that is transmitted is utilized for the purpose of adjusting the power in the Power-Adaptive Non-Orthogonal Multiple Access (PANOMA) system. The PANOMA algorithm contributes to the enhancement of the Bit Error ratio and concurrently reduces the computational complexity.

1.1 ADVANTAGES OF PD-NOMA

- ✓ Increased Spectral Efficiency
- ✓ Enhanced Capacity
- ✓ Flexibility and Adaptability

1.2 CHALLENGES OF PD NOMA

- ✓ Interference Management
- ✓ Complex System Design
- ✓ Quality of Service (QoS)

The biggest challenges observed in contemporary Non-Orthogonal Multiple Access (NOMA) systems pertain to the constrained availability of channel feedback and the complexities associated with integrating them with sophisticated adaptive coding and modulation techniques. The NOMA system incorporates the 5G technology with the objective of achieving reduced latency, enhanced spectral efficiency, and equitable distribution of resources among users. The NOMA technique facilitates the concurrent utilization of radio frequency resources by many users possessing varying power levels. The current Orthogonal Multiple Access (OMA) technology exhibits elevated latency, computational complexity, and throughput difficulty when it comes to altering wireless channels. In order to address the aforementioned challenges, this study introduces a novel approach that involves enhancing the performance of power domain non-orthogonal multiple access (NOMA) using a deep learning framework based on Long Short-Term Memory (LSTM) and optimizing it through the application of Particle Swarm Optimization (PSO) technology. The suggested study, referred to as LSTM-PSO, utilizes a Cooperative network model.

2. Related Works and its background

- Jul, [1] presented a novel transmission model, namely CMRS-NOMA, for cellular networks. The suggested approach utilizes successive interference cancellation (SIC) to decode the receptions from the source to numerous relay nodes. This paper presents both exact and asymptotic equations for the feasible symbol rate (SR) and outage probability of the proposed system over independent Rayleigh fading channels. Furthermore, we conduct a qualitative analysis on the intricacy of the multi-stage power distribution technique. It is readily apparent that the decoding of all signals can be accomplished in a straightforward and efficient manner.
- Dutta, [2] examines a system with a single input and single output (SISO) configuration, utilizing a quadrature phase shift keying (QPSK) signal constellation. The numerical findings indicate a notable enhancement in Bit Error Rate (BER) when compared to the currently employed techniques. However, it is important to note that this strategy incurs a significant increase in computational complexity. In conventional practice, Non-Orthogonal Multiple Access (NOMA) demonstrates enhanced spectrum efficiency in comparison to its orthogonal cousin. However, despite this, our suggested method will retain this characteristic while also offering improved bit error rate performance. It should

be noted, however, that the spectrum efficiency of our solution will be lower in comparison to the conventional power (NOMA) access approach based on sum-rate.

- Kara & Kaya, [3] focuses on the impact of power allocation coefficient on the performances of Deep learning-NOMA users, as determined by the numerical results obtained from the proposed equations. The findings indicate that the coefficient has a significant impact on user performance. The adaptation of the power allocation coefficient is shown to be necessary in accordance with the channel conditions between the base station (BS) and the user, in addition to the transmitted signal-to-noise ratio (SNR).The BER performances of users in NOMA are mostly influenced by the disparity in channel characteristics and power levels across users. However, it should be noted that increasing the transmit powers of both users does not guarantee an improvement in performance. According to the numerical findings, Non-Orthogonal Multiple Access demonstrates efficiency in scenarios where the distances of users from the Base Station vary.
- Kumaresan, [4] proposed DNN-UC scheme can achieve near-optimal performance in terms of throughput with the best hyper-parameters, which is roughly 97% of the throughput attained by the B-FS-UC method. In addition, the DNN-UC's robustness is assessed in several NOMA contexts, demonstrating that the suggested approach is adaptable and resilient to multiple NOMA situations without requiring model re-training. Nevertheless, due to the intricate structure of the proposed approach, which encompasses several tiers of processing and nonlinear conversions, the training procedure of the DNN-UC exhibits a reduced pace, while the computational intricacy during the testing phase surpasses that of the ANN- User Clustering.
- JYang, [5] addresses the aspect of dynamic user change. The primary objective of this research is to investigate the management of resources issue in the NOMA structure, with a special emphasis on the deployment of inadequate successive interference cancellation (SIC) technology at the reception. Allocations for power and user time management are two focal points of the study. The DL model employs a safe nonlinear transformation to generate results for the user, specifically in the context of clustering prediction with optimal throughput.
- Gao, [6] make use of the MISO-NOMA network that is assisted by intelligent reflecting surfaces. A combination of three approaches is suggested for addressing the stated issue. In specifically, an algorithm based on long short-term memory (LSTM) is first implemented to foretell user movement. By maximizing the passive beam-forming vector

and the power allocation efficient vector simultaneously under the QoS constraint, a problem was constructed to maximize the sum rate. Three machine learning techniques were presented to solve the issue, one each for predicting user mobility, grouping people into clusters, and designing the phase shift matrix.

- Shirvanimoghaddam, Liu, Ding, et al [7-10] make use of the hybrid strategy for allocating bandwidth and transmission power. In specifically, an algorithm based on sum rate reduction and max-min fairness.
- Dhakal, Pan, Abdel Moniem, et al [11-12]. The objective of this research is to investigate the MIMO, Ultra-massive wireless connectivity to improve the spectrum efficiency.
- Hedayati, Bariah, Ali, et al [13-15] Proposed DL-based approaches and to reduce the computation time and power consumption.

3. OBJECTIVES THE RESEARCH

i. It is suggested to combine deep learning with the evolutionary technique known as DNN-PSO for user selection and coupling in PD-NOMA for both the currently available 5G networks and the future 6G networks. Using the newly obtained dataset, the suggested model undergoes training, is then verified, and finally is assessed. The suggested PD-NOMA model has been shown to be effective thanks to the multiple assessments that have been carried out in terms of loss, PSNR, efficiency, rate of learning selection, and resource.

ii. To propose the construction of a Power-adaptive NOMA (PANOMA) with multi-point coordinates, in which the energy parameters for various users are chosen taking into consideration the average error probability for all users. Also to show that BER can be improved for a number of different consumers.In order to put the suggested technique to practice, the BER effectiveness has been proved by experimentation. This essential effort, which will lead and drive future progress in this subject, is hampered to a significant extent by the complexity of its computational requirements.Power Adaptive NOMAfurther reduces BER by assigning distinct powers to the in-phase and quadrature elements for each user.

iii. To propose a novel channel estimation technique utilizing Long Short-Term Memory (LSTM) with Particle Swarm Optimisation to enhance the outage probability, bit error rate (BER), and user sum rate of the conventional NOMA systems. The proposed power coefficient allocation algorithm distributes power among N users based on their

individual channel conditions. The efficiency and feasibility of using LSTM induced with the PSO optimization algorithm in a cooperative network of NOMA model have been demonstrated for improving the BER in 5G networks.

4. CONTRIBUTIONS OF THE RESEARCH

a. Selecting and Pairing Future PD-NOMA Users

During uplink transmission, several users simultaneously utilize the same resources in order to send their signals to the base station (BS). The Deep Neural Network (DNN) with the Particle Swarm Optimization (PSO) model is used in the process of selecting the participants and creating compatible pairs for them. The BS, with the aid of the SIC (Serial Interference Cancellation), determines which communications belong to the users. In NOMA, the transmit power for the uplink and the downlink are identical to one another. There is a possibility that the SINR at the base station will display a very tiny variation depending on the specific channel conditions of each individual user.

NOMA's uplink and downlink SIC operations also differ. In the case of when there are two users, X and Y, the signal of user X will no longer be affected by the interference caused by user Y. This is achieved by identifying the robust signal coming from user Y, modulating it, and then subtracting it from the overall signal. SIC is conducted on strong users in the downlink in order to balance out the interference caused by weak users. In contrast, the SIC operation is carried out by the base station in uplink NOMA. This allows the base station to differentiate between powerful users, such as X, and weak users, such as Y, by considering the latter as interference. In order to determine who user X is, the signal is first demodulated, and then interference is taken out of the equation. The suggested model is evaluated using theoretical and simulated PSNR metrics, and it achieves enhanced PSNR values of 35 dB and 34 dB, respectively, when employing these measures. When it comes to throughput, the model that was suggested was successful in achieving a safe rate of 9.6Mbps for a total of 50-100 users.

The proposed model outperforms other approaches. Throughput and the number of epochs are taken into consideration when assessing the performance of the model and a learning rate of 0.001 is used. After doing an analysis on the

energy efficiency of the NOMA schemes, a savings of 1290J for each of the 50 users was determined. The assessment and comparison show that the suggested model has a greater throughput and lower energy usage than the other models. This model is effective for use in upcoming wireless communication systems, particularly in terms of user selection and grouping; moreover, it improves the overall quality of service.

b. Power Adaptive Design for Improving Bit Error Ratio through Single and Multi-Point Non-Orthogonal Multiple Access

The second model for analysis has two distinct systems, specifically the Single-Input Single-Output (SISO) system and the Coordinated Multi-Point (CoMP) system. Every user is connected to the base station (BS). The concept of point-to-point and multi-point channels is inherent. The architectural design of the suggested model-1 is seen in Figure 1.

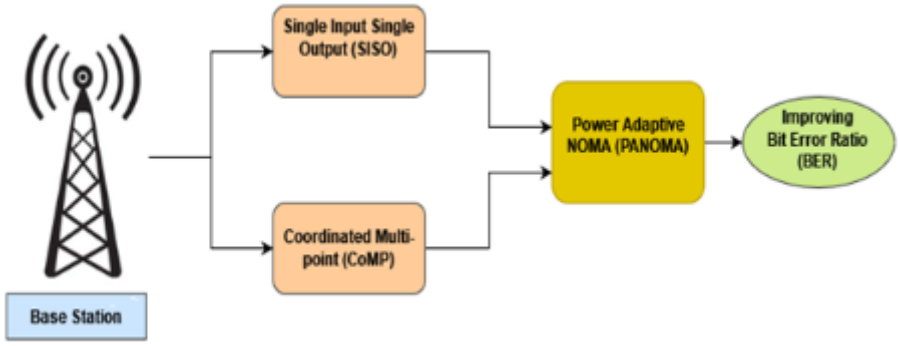

Figure 1. Architectural framework model-1 of the system

The suggested design has three main components: the system model, the PANOMA scheme, and the Many-to-Many channel. These components are designed to enhance both bit error rate (BER) and power allocation.

The Power Adaptive NOMA (PANOMA) scheme is offered as a means of assessing power allocations. The use of PANOMA enhances the system's resilience. The system employs Single-Input Single-Output (SISO) and Coordinated Multi-Point (CoMP) technologies for both the Base Station (BS) and Users. The considerable improvement of the Bit Error Rate (BER) is determined by the extension of the suggested system to incorporate Quadrature Phase-Shift Keying (QPSK) modulation. In order to decrease the bit error rate (BER), it is necessary to assign different powers to the in-phase and quadrature components for each user. The evaluation is conducted to assess the performance of both

systems in achieving a minimum limit and determining the PANOMA rise for Binary Phase-Shift Keying (BPSK) and Quadrature Phase-Shift Keying (QPSK).

The analysis examines the bit error rate (BER) performance of the power system utilizing the proposed power amplifier coordinated multi-point non-orthogonal multiple access (PA-CoMP-NOMA) technique. The investigation focuses on users and considers channel deviations ranging from 0 dB to 9 dB, with increments of 2 dB.To maintain simplicity, we use the assumption that every user possesses an equal variance of noise, denoted as 2w. It is also presumed that every user possesses the capability to flawlessly execute SIC decryption for customers at a lower level of the i^{th} user. A model that was not encoded was determined. In addition, we conducted an analysis on the imposition of a minimum charge of 0.2 bits per second per hertz for every user.

The bit error ratio in each of these systems is improved by the PA-CoMP-NOMA approach that was addressed. The overall BER may see an improvement as a result of this. NOMA has a better spectral efficiency in comparison to its orthogonal family member. However, despite the fact that its spectral efficiency is inferior to that of the traditional sum-rate based power NOMA, the approach that we have suggested is able to preserve this characteristic while also providing improved BER performance.

c. Optimized LSTM In Cooperative Networks for PD-NOMA Deep Learning Technique

The implementation of 5G technology necessitates the use of a non-orthogonal multiple access system in conjunction with a Long Short-Term Memory Particle Swarm Optimization in a cooperative network. The use of downlink and power domain may be improved in a cooperative network by using a direct transmit connection between the base station and its users in the cluster. This enables multi-users to boost performance inside the network. When distributing resources, the transmission power of different users varies due to near-far difficulties. The architectural design of the planned work is seen in Figure 2.

Hence, it is necessary to utilize the successive interference cancellation (SIC) procedure in order to identify the signals emitted by the user. The NOMA technique has the capability to identify the power domain by analysing the temporal and spectral characteristics of users. There are two distinct sorts of NOMA ideas that are now

accessible. There are two distinct categories of NOMA systems, namely cooperative NOMA and non-cooperative NOMA.

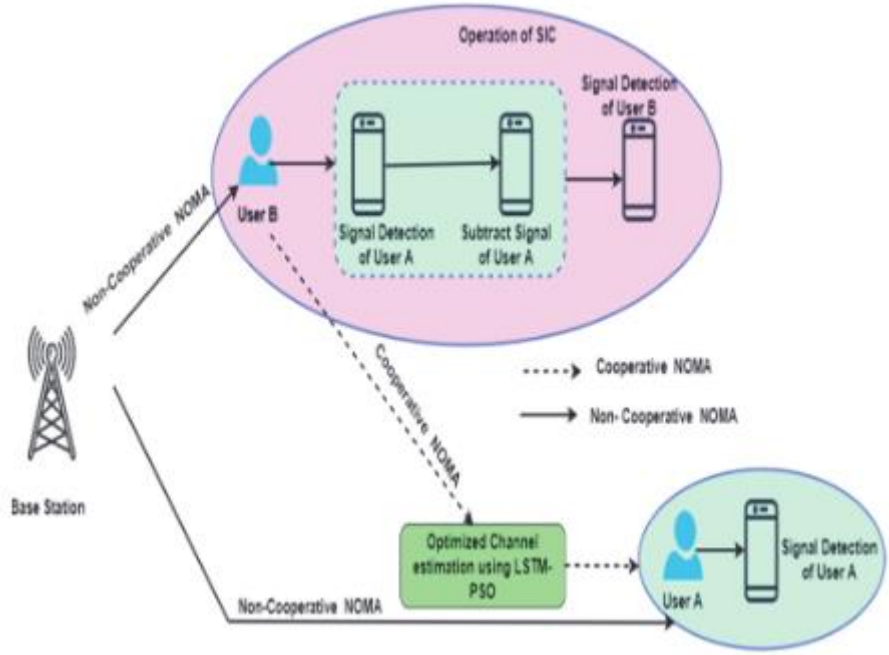

Figure 2. Architectural Framework Design Model-2 of the System

In the context of non-cooperative NOMA, the process of successive interference cancellation (SIC) is used to identify and separate the signal sent by the reference user. This signal is then reconstructed, while the signal transmitted by the other user is disregarded if its power exceeds that of the reference user. Hence, when the base station is in close proximity to the user, the signal is not subject to cancellation due to power management mechanisms, hence constituting the interference that adversely affects the operation of the system. In a similar vein, the cooperative NOMA structure effectively mitigates the impact of conflicting signals on users, prioritizing those in closer proximity to the base station. In the context of cooperative non-orthogonal multiple access (NOMA), the base station identifies and removes the users who are in closer proximity to it. This allows for the transmission of the distant user's (with higher power) signal to the base station, which is then replicated and sent to the far-powerful users. According to the information shown in the architecture, User B is in closer proximity to the Base Station (BS) and is classified as a strong user due to their use of SIC operation. The channel complexity is more pronounced.

The first step involves the detection of User A, who has a stronger signal. Subsequently, the received signal is adjusted by subtracting User A's signal before

proceeding with the detection of User B's signal. In this discourse, we will deliberate over the concept of cooperative non-orthogonal multiple access (NOMA). User B sends the signal detected from User A through wireless transmission. In the context of non-cooperative NOMA, the signal sent by User A experiences interference from the lower power signal transmitted by User B. However, the successive interference cancellation (SIC) technique fails to identify this interference.

5. EXPERIMENTAL RESULTS

In this section, an evaluation of the suggested model is conducted via simulation and contrasted against several Non-Orthogonal Multiple Access (NOMA) settings. In order to simulate the suggested model, the training data is collected and compiled without encountering any limitations related to sample size. The findings that were reported in this research demonstrate equilibrium, which can be attributed to the fact that the channel coefficients for each user over the various time periods were generated randomly in accordance with an exponential model. Deep learning and adaptive algorithms serve as the theoretical basis for the model that has been proposed. The NOMA channels are modelled using the MATLAB tool.

Table 1 : Comparison work of PD-NOMA with PANOMA and LSTM-PSO

Numbers of users	No of Users vs. Throughput changes(Mbps)			No of Users vs. Execution Time changes (s)		
	PD-NOMA	PANOMA	LSTM-PSO	PD-NOMA	PANOMA	LSTM-PSO
0 - 20	7	6	7.2	14.2	13.8	12.8
20 - 40	8	7.8	8.2	16.5	16.2	15.1
40 – 60	8.5	8.5	8.8	19.2	18.9	17.8
60 – 80	9	9.2	9.6	22.2	21.7	20.7
80 - 100	9.5	9.6	10.2	24.2	23.5	22.6

In the first stage, a comparative analysis is conducted between the proposed Long Short-Term Memory Particle Swarm Optimization (LSTM-PSO) approach and the PD-NOMA and PANOMA methods. The assessment criteria under consideration include variations in throughput and execution time as a function of the number of users. The suggested LSTM-PSO method has shown superior performance compared to previous approaches, as seen by the findings reported in Table 1.

Table 2 : Comparison work of LSTM-PSO with PANOMA and LSTM

Numbers of users	No of Users vs. PSNR changes(dB)			No of Users vs. Energy changes(J)		
	LSTM-PSO	PANOMA	LSTM	LSTM-PSO	PANOMA	LSTM
0 – 20	18	15	12	970	900	800
20 – 40	28	25	22	1190	1160	1070
40 – 60	34	32	30	1390	1350	1290
60 – 80	35	33	32	1590	1560	1470
80 – 100	36	34	33	1790	1750	1670

The subsequent phase introduces LSTM-PSO and proceeds to evaluate its performance in comparison to PANOMA and LSTM. The assessment criteria included in this study are the changes in Peak Signal-to-Noise Ratio (PSNR) and energy consumption, which are analysed in relation to the number of users. Table 2 displays the greatest PSNR (Peak signal to noise ratio) achieved by the suggested LSTM-PSO method, which is 36 Db. Additionally, it indicates that the maximum energy attained is 1790 Joules in relation to the users. This method demonstrates a higher level of effectiveness compared to the currently available systems.

6. CONCLUSION

In summary, the advancement of wireless communication has led to a realization of the growing limits associated with conventional orthogonal multiple access solutions. Several other evaluations, such as loss, PSNR, efficiency, rate of learning selection, and energy consumption, demonstrate that the PD-NOMA model that was suggested is effective. The analysis of training and validation loss is used to determine the appropriate number of epochs to use in the learning process. After 200 iterations, the values show signs of similar behaviour. When considering the transmission of image and video data, it is essential to minimize noise and strive for a model that exhibits an improved PSNR. In the second phase, the creation of a power adaptive NOMA with coordinate multi-point, in which the energy parameters for various users will be set taking into consideration the average error probability for all users, was described. It is shown that the BER can be improved for a number of different consumers. In order to put the suggested technique to practice, the BER effectiveness has been proved by experimentation. Evaluating channel conditions with boosting user activity, increasing the capacity of the base station, and improving the quality of service. and efficiency in power

allocation are some of the advantages that can be gained from using LSTM-PSO in cooperative networks. Other advantages include high performance, better utilization of downlinks, efficiency in sharing resources, and estimation of channel condition. The accuracy rate for LSTM-PSO was 92.05%, while the accuracy rate for LSTM was 86.45%, PSO was 88.13%, and the accuracy rate for ANN and DNN was 83.76% and 84.70% respectively. In further work, it is possible that this work will be expanded up to tackling decrease in complexity, adopting new deep learning or machine learning approach for effectively detecting channel and data.

7. ORGANIZATION OF THESIS

Chapter 1 describes the introduction about Wireless sensor networks (WSNs), and mainly its interaction with 5G communication systems which include its overview and its components, design constraints on the concepts of Non-Orthogonal Multiple Access (NOMA), its comparison with alternative techniques and associated issues.

In **Chapter 2** the literature study has undergone substantial development in order to enhance multiple access methods in the fifth-generation (5G) cellular network. This includes doing quantitative analysis of the suggested model and comparing it with current models. Each of the works of literature examined the principles, advantages, and disadvantages of its suggested model.

In **Chapter 3,** a novel Selecting and Pairing Future PD-NOMAUsers is proposed. The objective of this method is to address the challenges associated with energy consumption in PD-NOMA networks. This chapter presents an examination of the PD-NOMA model, which demonstrates its ability to produce reduced energy usage and increased throughput when compared to other models. This chapter describes the proposed mechanisms architecture, workflow, and performance efficiency in detail.

In the **Chapter 4,** the proposed work is focused in the use of Power Adaptive Design in the context of enhancing Bit Error Ratio in NOMA systems. The purpose of the assessment is to analyse the performance of both systems in obtaining a minimal threshold. The PA-CoMP-NOMA technique discussed in this study improves the bit error ratio in each of the aforementioned systems.

In **Chapter 5,** the proposed study investigates and analyses the use of a non-orthogonal multiple access system in combination with LSTM-PSO which offers several advantages, including high performance, improved downlink utilization, efficient resource sharing, enhanced user activity, increased base station capacity, improved quality of service, and accurate channel condition estimation.

In **Chapter 6,** an overview of the main findings and implications of the study is summarized, followed by a discussion on future possibilities for further research.

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9. LIST OF PUBLICATIONS

1. Kavitha, G., and J. Deny. "Single and Multi-Point Non-Orthogonal Multiple Access based Power Adaptive Design for Improving Bit Error Ratio." Measurement Science Review, **23 (**4) (2023), 184-191.
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3. Kavitha, G., and J. Deny. " User Selection and Pairing for Future Power Domain Non-Orthogonal Multiple Access (PD-NOMA) using Deep Learning Techniques " International Journal on Recent and Innovation Trends in Computing and Communication,**10** (1) (2022), 304-311.